Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

University of Maine.

Maine Agricultural Experiment Station

ORONO

BULLETIN No. 204. SEPTEMBER, 1912.

TRIPLET CALVES

This bulletin gives a detailed description of a set of triplet calves, produced by a cow with a hereditary tendency towards multiple gestation. The bearings of the case on some general problems of practical and theoretical animal breeding are discussed.

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE.

THE STATION COUNCIL.

PRESIDENT ROBERT J. ALEY,	*President*
DIRECTOR CHARLES D. WOODS,	*Secretary*
CHARLES L. JONES, Corinna,	*Committee of Board of Trustees*
FREELAND JONES, LL. B., Bangor,	*Committee of Board of Trustees*
JOHN M. OAK, B. S., Bangor	*Committee of Board of Trustees*
JOHN P. BUCKLEY, Stroudwater,	*Commissioner of Agriculture*
EUGENE H. LIBBY, Auburn,	*State Grange*
ROBERT H. GARDINER, Gardiner,	*State Pomological Society*
RUTILLUS ALDEN, Winthrop,	*State Dairymen's Association*
WILLIAM H. DAVIS, Augusta,	*Maine Livestock Breeders' Association*
WILLIAM G. HUNTON, Readfield,	*Maine Seed Improvement Association*

AND THE HEADS AND ASSOCIATES OF STATION DEPARTMENTS.

THE STATION STAFF.

ADMINISTRATION	CHARLES D. WOODS, Sc. D.,	*Director*
	BLANCHE F. POOLER,	*Clerk and Stenographer*
	GEM M. COOMBS,	*Stenographer*
BIOLOGY	RAYMOND PEARL, PH. D.,	*Biologist*
	MAYNIE R. CURTIS, A. M.,	*Assistant*
	CLARENCE W. BARBER, B. S.,	*Assistant*
	WALTER ANDERSON,	*Poultryman*
	ESTELLA MORRISON,	*Computer*
CHEMISTRY	JAMES M. BARTLETT, M. S.,	*Chemist*
	HERMAN H. HANSON, M. S.,	*Associate*
	ALBERT VERRILL, B. S.,	*Assistant*
	EDWARD E. SAWYER, B. S.,	*Assistant*
	HELEN W. AVERELL, B. S.,	*Assistant*
	HARRY C. ALEXANDER,	*Laboratory Assistant*
ENTOMOLOGY	EDITH M. PATCH, PH. D.,	*Entomologist*
	ALICE W. AVERILL,	*Laboratory Assistant*
PLANT PATHOLOGY	WARNER J. MORSE, PH. D.,	*Pathologist*
	CHARLES E. LEWIS, PH. D.,	*Associate*
	VERNON FOLSOM,	*Laboratory Assistant*
HIGHMOOR FARM	WELLINGTON SINCLAIR,	*Superintendent*
	GEORGE A. YEATON,	*Orchardist*
ROYDEN L. HAMMOND,		*Seed Analyst and Photographer*
ELMER R. TOBEY, B. S.,		*Inspector*
EDGAR WHITE,		*Inspector*
CHARLES S. INMAN,		*Assistant*

S69
.E4
Ag. 2.10/21/13

BULLETIN No. 204.

A CASE OF TRIPLET CALVES: WITH SOME GENERAL CONSIDERATIONS REGARDING MULTIPLE GESTATION IN NORMALLY UNIPAROUS ANIMALS.[1]

By Raymond Pearl.

Introduction.

Some five years ago the writer became interested in the general subject of the occurrence of multiple gestation in animals normally bearing but one young at a birth, through having his attention called to a case of triplet calves. A brief preliminary notice of the case was published at the time.[2]

It was then intended immediately to follow this note with a more detailed discussion of the case. As material was collected in the preparation of that paper, however, it soon became evident that such cases of multiple pregnancy presented a number of features of interest in connection with certain general problems of biology. As time went on it seemed desirable to extend the scope of the inquiry. Accordingly I have been collecting notes and data on the general subject during the past four years. It seems desirable now to put some of these notes together for publication.

There are four general biological problems to which cases of multiple gestation relate and upon which we may reason-

---

[1]Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 39.

[2]Pearl, R. A Case of Triplet Calves with Peculiar Color Inheritance. Science, N. S. Vol. 26, p. 760, 1907.

ably expect light to be thrown by the analysis of such cases. These problems may be briefly designated as follows:

1. The physiological problem.
2. The problem of sex determination.
3. The problem of secondary sexual characters.
4. Certain problems of inheritance.

The mere fact of the occurrence of multiple pregnancies in forms normally bearing but one young at a time presents a deeply interesting problem in the physiology of reproduction. It means that the reproductive mechanism is not functioning in the normal or usual manner. But just where and what is the change from normal? Is the occurrence of twins and triplets due to a departure from the normal in the functioning of the ovary, or of the tubes and uterus? Or in a word what is the *physiological* basis of the occurrence of multiple gestation? It is, of course, an observation as old as history itself, that in the great majority (if not all) mammals where one young at a birth is the normal condition multiple gestations occasionally occur. Even in man, nearly the slowest in rate of reproduction of all mammals, there are occasionally as many as 4, 5, or 6 young at a single birth.[3]

Yet in spite of the fact that the phenomenon of multiple pregnancy is so well known, data are wanting as to the underlying physiological causes upon which such occurrences depend. It is not to the point to contend that normally uniparous animals showing an occasional multiple gestation are descendants (in the course of evolution) from forms normally multiparous, and that the occurrence of multiple gestations now is an "ancestral reminiscence". This may all be true but it tells us noth-

---

[3]It is not necessary to cite the literature on this subject here *in extenso*. I merely give, by way of illustration for those who may be curious about the matter, a few references from recent literature.

Wilkins, S. V., Birth of Quadruplets Jour. Amer. Med. Assoc. Vol. 49, p. 43, 1907.

Berheim, A., Quintuplets. New York Med. Jour. Oct. 22, 1904, pp. (of reprint) 1-6.

Miknovski, Yu. I., [Quintuplets] J. akush i jensk. boliez., St. Petersburg. Vol. 22, pp. 79-85. 1908.

Wickersheimer, E., Une observation inédite de grossesse sextuple. Bull. soc. d'obst. de Paris. T. xii, p. 320, 1909.

69
E4

ing about the physiological causes which determine that in the breeding history of a particular individual, twins are born at, let us say, the fourth pregnancy, while from all other pregnancies in the life of the animal only single young come. From whatever angle we approach the matter it is clear that there must be a definite (and presumably determinable) set of causes in the physiology of either the ovaries or Fallopian tubes and uterus, or both which leads to the production of twins. In the hope of getting light on this problem the collection of the most complete information possible in regard to multiple gestation in normally uniparous forms is to be desired. This is a matter in which stock breeders may give valuable aid.

2. The problem of sex determination is one very much in the foreground of biological interest at this time. The work of the last 10 years seems to have made some really definite progress towards the final solution of the problem. A number of different lines of research just now being prosecuted vigorously all lead to the same general view as to the basis of the causation of sex. In the first place the cytological researches of McClung, Wilson, Stevens and Morgan,[4] and others indicate that in many forms of life, at least, there are constant and characteristic differences between the sexes in respect to the number, form and size of the chromosomes and that further the behavior of the chromosomes of the reproductive cells during their maturation and fertilization is of the sort which would be expected to occur if, in the first place, sex were inherited and, in the second place, this inheritance were controlled by certain of the chromosomes. Supplementing this cytological evidence and leading to the same conclusion that sex is a definitely inherited character, are the experimental researches in which sex is shown to behave in the same manner that structural char-

[4]It is not necessary to cite in detail here references to all papers of the workers in this field. An extensive bibliography is given in Morgan, T. H., "A Biological and Cytological Study of Sex Determination in Phylloxerans and Aphids." Jour. Exper. Zoöl. Vol. vii, pp. 239-352, 1909. Summary accounts of the cytological work on sex determination are to be found in Wilson, E. B. "Recent Researches on the Determination and Heredity of Sex," Science, N. S. Vol. 29, p. 53, 1909 and in Doncaster, L., "Recent Work on the Determination of Sex." Science Progress, No. 13, pp. 90-104, July 1909. See also the more recent summary by Professor Wilson, "The Sex Chromosomes," Arch. mik. Anat. Bd. 77, pp. 249-271, 1911.

acters do in Mendelian crossings. As pioneer work in this field stand the brilliant experiments of Doncaster and Raynor with *Abraxas,* those of Bateson and Punnett with the silky fowl, and those of Miss Durham on canaries.[5]

More recently sex-limited inheritance (in which sex behaves as a Mendelian character) has been further studied in fowls by Goodale, Hagedoorn, Sturtevant and others.[6]

The same type of inheritance has been shown by Morgan[7] to hold for a number of characters in the pomace fly, *Drosophila.*

The evidence, now considerable in amount, from both the cytological and experimental lines of investigation, indicates clearly that sex determination is not, as it was long supposed to be, primarily an epigenetic phenomenon. Rather does it appear that the sex of the individual, into which a particular pair of united germ cells will develop, is definitely and unalterably fixed in the hereditary constitution of these germ cells themselves.

In view of these well established conclusions the facts regarding the distribution of sex in cases of multiple gestation take on a peculiar interest. It has long been a well known statistical fact that the sex ratios of offspring resulting from multiple gestation in animals normally uniparous present distinct deviations from the normal. Thus it has recently been shown by Nichols,[8] after careful analysis of the available sta-

---

[5]References to this earlier work are given in Bateson, W., Mendelian Principles of Heredity. Cambridge, 1909, pp. 174-188.

[6]Goodale, H. D. Sex and its Relation to the Barring Factor in Poultry. Science, N. S. Vol. 29, No. 756, pp. 1104, 1105, 1909.

Hagedoorn, A. L., Mendelian Inheritance of Sex. Roux's Archiv. Bd. 28, pp. 1-34.
1909.

Pearl, R. and Surface, F. M. On the Inheritance of the Barred Color Pattern in Poultry. Roux's Archiv. Bd. 30, pp. 45-61, 1910.

———— ———— Studies on Hybrid Poultry. Rept. Maine Experiment Station, 1910, pp. 84-116.

———— ———— Further data regarding the Inheritance of the Barred Color Pattern. Science, N. S. Vol. 32, pp. 870-874, 1910.

[7]Morgan, T. H. Sex Limited Inheritance in Drosophila. Science, N. S. Vol. 37, 1910.

An Attempt to Analyze the Constitution of the Chromosomes on the Basis of Sex-Limited Inheritance in Drosophila. Jour. Exper. Zoöl. Vol. 11, 1911. Also a number of other papers on this subject.

[8]Nichols, J. B. The Numerical Proportions of the Sexes at Birth. Mem. Amer. Anthropol. Assoc. Vol. I, Part 4, pp. 249-300, 1907.

tistics for man, that here the number of sons for a thousand daughters drops from 1057 for single births to 548 for quadruple births. That this decline is progressive is shown by the table given by this author (*loc. cit.* p. 298) which is here reproduced.

	Number of Sons for 1000 Daughters.
Single births	1057
Twin births	1043
Triple births	1007
Quadruple births	548

Such a preponderance of females in multiple births is not confined to the human species. The same thing is true of multiple births in sheep and other usually uniparous animals. The obvious explanation which suggests itself to account for these deviating ratios is a prenatal mortality which is differential in respect to sex. It is well known, from statistical studies of the matter in man, that the prenatal rate of mortality is greater for males than for females. If, as seems reasonable *a priori,* the conditions of foetal existence become more severe as the number of young borne in the uterus at the same time increases, any inherent differences in respect to foetal mortality rate between males and females might be expected to be accentuated by these conditions. The figures quoted from Nichols show exactly the trend which would be expected if there were an increasing proportion of deaths of male embryos with multiple gestations of advancing order. There are, however, certain facts which make it very doubtful indeed whether any significant portion of the observed disturbances in the sex ratio in multiple gestations are due to differential prenatal mortality. In the first place the same change in the sex-ratio is observed in multiple gestations in domestic animals where the prenatal mortality is insignificant in amount. In the second place the known facts regarding the distribution of the sexes in multiple births do not accord with the sex-differential prenatal mortality hypothesis.

The preponderance of females is not the only disturbance of the normal single birth sex ratios which occurs in multiple gestations. Another, and probably even more significant deviation is that which concerns the distribution of individuals of the two sexes in the sets of offspring born together. If indi-

viduals born as twins. for example, exhibited the same distribution in respect to sex as do random pairs of individuals born singly, it would be expected that twins would show the following sex relations.

Sex of twins:	♂♂	♂♀	♀♀
Frequency of occurrence:	*n* :	*2n* :	*n*

Actually multiple births in man and the domestic mammals show nothing of the kind. For example, Nichols *(loc. cit.)* gives the following figures for human twins.

Sex of twins:	♂♂	♂♀	♀♀
Observed frequency of occurrence:	234.497	: 264.098	: 219.312
Expected frequency if the distribution of sex within the pair was a random one:	179.476.75	: 358.953.50	: 179.476.75

A discussion of this curious phenomenon of sex distribution will be published in a later paper.

In addition to such disturbances of the sex ratio there also occur in connection with multiple gestation cases of apparently incomplete sex determination, such as those leading to the production of so-called "free-martins."

3. Mention has been made of free-martins. Not only do these animals furnish interesting data in regard to the determination of primary but also of secondary sexual characters. In many cases free-martins have been considered to be hermaphrodites, on the basis of their external appearance. In other cases such individuals are notably feminine in their characteristics, so much so indeed as to be used for show or demonstration purposes because they are so typical of the females of the race.

A classical example of this kind is found in the Short Horn breed in the case of the famous "White Heifer that Travelled." [9]

[9] For an account of this animal see Sanders, A. H., "Short-Horn Cattle." Second Edition. Chicago, 1901, pp. 41 and 42. This account is evidently copied, almost verbatim, from that given in Allen, L. F., "History of the Short-Horn Cattle. Their Origin, Progress and Present Conditions." Buffalo, (publ. by the Author), 1872, p. 52. This "white heifer," which was widely exhibited about 1806 as a typical specimen of the breed, was a free-martin. She was one of a pair of twins of which the other was a bull, and she herself did not breed. She was a very heavy animal, her weight at slaughtering having been estimated to be not less than 2300 lbs. The picture of this "White Heifer" given by Sanders (*loc. cit.*), presumably copied from some contemporary print, shows her to have been typically feminine in appearance. This agrees with the statements regarding this specimen which have come down to us.

The relation between primary and secondary sexual character in these free-martins obviously presents a problem of considerable interest.

4. Cases of multiple gestation present two interesting problems in inheritance. One of these concerns the degree to which a tendency toward multiple gestation in a normally uniparous form may be inherited. Are the offspring of a mother having this tendency likely to show it also? Comparatively little detailed work has been done upon this subject though a general impression appears to prevail that such tendencies are inherited. Thus Wilder[10] says regarding one particular sort of multiple gestation, viz., the production of duplicate twins. (*loc. cit.* p. 368:) "As the tendency to produce duplicate twins and other sorts of abnormal cosmobia seems inherent in certain organisms, and to be transmitted by heredity, it is quite possible that we may be able to breed certain of the viable forms."

There have been a few detailed studies on the inheritance of the tendency towards multiple pregnancies. In man Weinberg[11] and Oliver[12] have recently investigated the influence of heredity on twin bearing. Weinberg's paper is by far the most thorough study of the subject which has yet appeared. From a careful analysis of copious statistics he concludes that the tendency towards multiple pregnancies is inherited in Mendelian fashion, this character apparently behaving as a recessive. He regards heredity as having a greater influence in the production of multiple gestation than any other one factor. It was found impossible to account satisfactorily for the facts on the assumption of blending inheritance. While any single external factor certainly has less influence than heredity in causing multiple gestation, still the sum total of all such external influences must outweigh heredity in affecting observed variations in the num- outweigh heredity in bringing about observed variations in the

[10]Wilder, H. H. The Morphology of Cosmobia; Speculations concerning the Significance of Certain Types of Monsters. Amer. Jour. of Anat., Vol. 8, pp. 355-440, 1908.

[11]Weinberg, W. Die Anlage zur Mehrlingsgeburt beim Menschen und ihre Vererbung. Arch. f. Rass. u. Gesellsch. Biol. Bd. 6, pp. 322-339, 470-482, 609-630. 1909.

[12]Oliver, James. The Hereditary Tendency to Twinning, with some Observations concerning the Theory of Heredity generally. Part I. Eugenics Rev. Vol. IV, pp. 39-53, 1912.

number of young per birth in the breeding history of the *same individual* female, unless one is prepared to assume a very complicated mechanism of heredity for this character.

The relation of heredity to multiple gestation in man has also been discussed by Wakley,[12] Lop,[14] Naegeli-Akerblom,[15] and Rosenfeld[16] particularly, and by a number of other medical and and anthropological writers incidentally.

An interesting case of apparent inheritance of a tendency to twin bearing in cattle has recently been reported by Wentworth.[17] The family of cattle concerned has been bred on an old farm near Cocheco, New Hampshire. "The foundress of the family was a grade Holstein cow, herself a twin about seven years old. She has been on the farm ever since she was dropped and has given birth to seven calves. Her first service was to a Guernsey bull and resulted in a pair of yellow and white heifers one of which is now in the herd. Her second mating to a red Shorthorn bull resulted in a single black and white bull calf that was vealed. An Ayrshire bull sired her third calves, twin black and white bulls, but neither of these were good enough to raise. Her fourth service was to a Holstein bull and from it she produced twin black and white heifers that promise well as milkers."

"The yellow and white twin first produced by the old cow is now four years old and has twice borne twins. To an Ayrshire bull she produced a pair of yellow and white bull calves that early went to the butcher, and to a Holstein bull she gave birth to twin black and white heifers last December."

The further collection of accurate data bearing upon this question of the inheritance of a tendency to multiple gestation is greatly to be desired.

Data on a second problem in inheritance are presented by cases of multiple gestation, namely that of the limits of heredi-

---

[12]Wakley, Thomas. The Influence of Inheritance on the Tendency to have Twins. Lancet, 1895, Vol. II, pp. 1289-1290.

[14]Lop. Quelques chiffres sur l'hérédité de la grossesse jumellaire. Congrès périodique de gyn. obstétr. et de pédiatrie. Marseille, 1899.

[15]Naegeli-Akerblom. Die Geminität in ihren erblichen Beziehungen, Virchow's Arch. Bd. 170, 1902.

[16]Rosenfeld. Zur Frage der vererblichen Anlage zur Mehrlingsgeburten. Zeitschr. f. Geburtsh. u. Gynäk. Bd. 50, 1903.

[17]Wentworth, E. N. Twins in Three Generations. Breeder's Gazette, Vol. lxii, p. 133, July 24, 1912.

tary control. An important question in all such cases concerns the germinal genesis of the individuals included in the multiple pregnancy. Did the individuals thus growing together in the uterus arise from the separated blastomeres of a single ovum, or from several distinct ova? In most cases the only data which can be obtained on this matter arise from an examination of the external somatic characters of the individuals concerned to see whether or not they are identical.

It should be understood that the preceding, somewhat detailed, statement of the more important general biological problems to which cases of multiple gestation relate, is made for purposes of general orientation in regard to specific data discussed in this paper. It is also hoped that it may serve to indicate the kind of information that it is desirable to have recorded by those who may chance to be able to observe cases of multiple birth in the domestic animals. It is evident from the discussion given above that cases of this sort have significance for the biologist and the stockbreeder quite beyond the merely casual curiosity which they excite as "freak" occurrences. From the standpoint of the practical breeder it is highly important that the phenomenon of multiple gestation in normally uniparous animals be carefully studied. Any definite and heritable increase in the fecundity and fertility of the domestic animals, if it can be gained without loss of other desirable qualities, is greatly to be desired. Cases of multiple gestation are the "favorable variations' which must serve as the foundations for the creation of more fertile breeds and races. What may be accomplished in this direction has been splendidly demonstrated by the work of Dr. Alexander Graham Bell with sheep (see footnote p. 275).

Finally it should be said that this general introduction is distinctly not to be regarded as a statement of problems which are to be definitely and completely solved by the data presented in this paper.

Description of a Case of Triplet Calves.

This study has to do with a family of triplet calves[18] born near Waldoboro, Maine in 1907.

The facts regarding the birth and subsequent history of these calves are as follows:

1. *Birth.* The birth of the triplet calves occurred at Mr. L. A. Starrett's farm during the forenoon of June 20, 1907. There were present two other witnesses besides Mr. Starrett. On account of the previous breeding behavior of the mother of these calves (cf. p. 276 *infra*) there was thought to be considerable likelihood of a multiple birth in this case, and the cow was closely watched as the time of parturition approached. No exact record was kept as to the time taken in the parturition of these triplets, but it occupied several hours. There was a rest for a considerable time after the birth of the first two of the calves. The parturition was natural no aid in delivery being necessary. The birth order was ♀ : ♂ : ♀.

2. *Description of Calves.* As has been indicated two of the calves were females and one a male. They were stated to have been small at birth (as would of course be expected), but entirely normal in appearance and in activity. Unfortunately no record was made of the weights of the individuals at birth, so that it is impossible to determine how much below the average size for single calves these were. It is certain however, that while each individual was noticeably smaller than a normal single calf the *aggregate* weight at birth of the triplets was much above that of a normal single calf. All existing evidence regarding cases of multiple birth in species where unit births are normal points to the conclusion that while there is a reduction of size of individuals in the multiple births this reduction is not proportionate to the number of individuals. Thus it has been shown by Mumford[19] that in the case of sheep the

[18] The writer is under great obligation to Mr. James S. Walter of Waldoboro, Maine, the second owner of these calves, and to Mr. L. A. Starrett of Pleasant Point, Maine, who was the original owner, for the aid which they have freely and kindly given in this work.

[19] Mumford, F. B. Breeding Experiments with Sheep. I. Some Factors Influencing the Weight of Lambs at Birth. II. Milk and Food Records of Ewes. Missouri Agr. Expt. Stat. Bull. 53, pp. 167-188. 1901.

average birth weight of single lambs (of both sexes taken together) is 7.8 lbs. while the average birth weight of twin lambs is reduced only to 7.07 lbs. Vierodt[20] gives for the normal weight of the new-born human infant in round numbers 3250 gm. and for the weight of a single twin (regardless of sex) 2501 gm. (Fesser's data) or 2185 gm. (Recht's data). Again to consider multiple gestations of higher order, Wilking (*loc. cit.*) gives the following birth weight[21] for his case of quadruplets

Birth order and sex	Weight
1. ♀	1347 gm.
2. ♀	1247 "
3. ♂	1347 "
4. ♀	1332 "
Total	5273 "

Corresponding data for Bernheim's (*loc. cit*) case of quintuplets are:

Birth order and sex	Weight
1. ♂	1814 gm.
2. ♂	1928 "
3. ♂	1928 "
4. ♂	1928 "
5. ♂	2268 "
	9866 "

In these cases the single individual is obviously heavier than it should be if it were to be strictly proportional inversely to the number of young born together. In the case of the quintuplets the total weight is more than 3 times that for a normal single birth infant, as given by Vierordt.

Similar relations hold for multiple births in cattle. In an interesting paper based on data taken from the Simmenthal Herd Book Strebel[22] gives the following data:

Mean birth weight	♂	calves	44 kg.
" " "	♀	"	40 "
" " "		twins	70 "

[20]Vierordt, H. Anatomische, Physiologische und Physikalische Daten und Tabellen zum Gebrauche für Mediziner. Dritte Auflage. Jena (Fischer) 1906. pp. vi. and 616.

[21]I have transferred the weights as given in the original in pounds and ounces to grams in this and the Bernheim quintuplet case, in order to make the figures more readily comparable with that from Vierordt for the single birth.

[22]Strebel, Die Tauglichkeit von Zwillingskalbern zur Zucht. Deutsche Landw. Presse, Jahrg. xxxvl, No. 84, pp. 897, 898, 1909.

This author further states that in cases of twins of opposite sex the male individual weighed at birth from 5 to 13 kg. more than the female.

The triplet calves here under discussion grew and developed in an entirely normal fashion. They were seen by the writer in October, 1907, and at that time were not individually much under sized. In a letter dated February 3, 1908, Mr. Walter states that the calves were weighed January 14, 1908, with the following results:

Individual	Weight
♂	304 lbs.
♀	278 "
♀	280 "

The close similarity of the two heifers in weight at this age is noteworthy. Commenting on the condition of the calves at the time of this weighing Mr. Walter says: "Farmers admit they are more [= larger] than the average calf about here. They are not fat but in good condition."

In a letter of November 17, 1908, Mr. Walter estimates the weight of the three animals to be at that time between 1400 and 1500 pounds. The two heifers of the triplets were killed and used for beef early in April, 1910. They weighed about 1000 lbs. Mr. Walter stated that the bull was considerably larger than the heifers, but was unable to give the exact weight.

The only detailed statement I have been able to find in the literature regarding the growth of triplet calves is that of Leathers.[23]

This is as follows (*loc. cit.*): "On September 23, 1883, my three-quarter grade Short-horn cow dropped three male calves from a very fine registered Short-horn bull. When six months old the three weighed 940 lbs; at nine months 1680 lbs, and when yearlings, even 2200 lbs., and had nothing but ordinary tame pasture since May 10, 1884."

These are rather meager data but it is of some interest to compare them with figures for the normal growth of Short-horn cattle. Such data have been given by Meek.[24] This author

[23]Leathers, F. F. [Growth of Triplet Calves.] Breeder's Gazette, Vol. 6, p. 609, 1884.

[24]Meek, A. Growth of the Farm Ungulates. I. Approach from a Study of the External Characters. Veterinarian, Vol. LXXIV (XLVII Fourth Series) pp. 121-126. 1901.

has prepared a table (*loc cit.* pp. 122, 123) showing the weight of Short-horn cattle at various stages from birth up to 3 years and 176 days for males and 7 years and 58 days for females. In this table the bulls and steers are lumped together, and the weights of cows are given in another column. Leathers (*loc. cit.*) gives the weight of his triplet calves at three ages; namely six months, nine months and one year. From data given in the column headed "Bulls and Steers" in Meek's table I have endeavored to calculate the weight of normal (i. e., single birth) Short-horn cattle at the same ages. As a necessary consequence of the method of collection Meek's data represent rather uneven intervals in age. The best it seems possible to do from this table in approximating normal mean weights of Short-horn males at the three specified ages is to take the records closest (on either side) to the required number of days and average the weights given for those ages. The table gives the weights of four individuals ranging in age from 173 to 201 days. Two of these individuals were 176 days old, one 173 days and the other 201 days. Averaging these four together to get an approximation to the normal mean weight at six months (180 days) of age, the result is 351.5 pounds. Similarly the table gives the weights of five individuals ranging in age from 265 days to 292 days. Averaging these together to get an approximation to the mean weight for age nine months (270 days) I get 505.6 pounds. The weights given range from 486 to 540 pounds. Finally to get an approximation to the normal weights of Short-horn males one year of age I have averaged together the weights of six individuals in the table ranging in age from 350 days to 1 year and 13 days. The weights of these individuals range from 672 pounds to 718 pounds and the average weight is 698.3 pounds. Putting all these data together for comparison with the figures of Leathers for the triplets we have the result shown in the following table. The figures tabled for the triplets are the mean weight per individual at each age, obtained by dividing the value given by Leathers by 3 in each case.

Weight of Calves in Pounds.

Age	Normal Short-horn Males. (Meek)	Triplet Short-horn Males. (Leathers)
Six months	351.5	313.3
Nine "	505.6	560.0
Twelve "	698.3	740.0

From these figures it is to be noted in the first place that although the triplet calves were at six months of age some 38 pounds below the normal in weight, by the time they had reached the age of nine months the mean weight per individual of the triplets was not only equal to the normal weight for Short-horn calves of the same age, but exceeded it by about 55 pounds. About this same degree of excess in weight was maintained during the next three months so that at one year of age the mean weight per individual of the triplets was 42 pounds above the normal as determined from Meek's data. It appears then in the case of triplets, just as is known to obtain with twins, that while the individuals start their free life at a lower weight than is normal for single animals yet this defect is compensated for in the subsequent growth. By the time the adult condition is reached there is no difference in regard to size relations between the individuals which originate from multiple and those which originate from single pregnancies.

These facts seem to me to be of considerable interest in connection with the dynamical hypothesis regarding growth recently published by Hatai.[25] It is to be presumed that in the case of twins coming from two ova the original endowment of the fertilized egg in respect to "potential growth energy" is the same as in the case of a single offspring. Further, at the end of the growth process both the twins and the single individual attain the same bodily size (or volume). But the curve of growth *up to the time of birth* must be considerably different in the case of the twin individuals from what it is in the single individual. During this period *do* the twins "grow at maximum

[25]Hatai, S. An Interpretation of Growth Curves from a Dynamical Standpoint. Anat. Record, Vol. 5, pp. 373-382. 1911.

rate with least loss of growth energy?" This point would seem well worth investigation in the light of Hatai's valuable hypothesis. It can, of course, be tested, as he has pointed out, by finding whether a logarithmic curve will fit the observed growth during the prenatal life of the twins. If so the hypothesis will be satisfied.

Still more interesting in the same connection is the case of enzygotic twins, where the two individuals originate from the same fertilized ovum. Such twins, so far as may be judged from the meager evidence available, grow to the same end adult size as individuals each developing from a single ovum and occupying the uterus alone during gestation. But if this is so it seems to raise a difficulty respecting the original endowment of potential growth energy in the fertilized egg cell from which the enzygotic twins arose. Did this fertilized egg have twice the usual amount of potential growth energy? If not, what is the source of the additional supply which makes each of the enzygotic twins go on growing to normal full adult size? It seems certain that the study of the growth, both prenatal and postnatal, of multiple young in animals normally bearing but a single offspring at a time, cannot fail to yield results of fundamental importance to the analysis of the normal physiology of growth.

We may turn next to a description of the color characteristics of the triplet calves. The three individuals were not all alike in color. The two females were very nearly alike but not absolutely identical. The male calf was quite different in color and color pattern from his two sisters. The general characteristics of the triplets in respect to color pattern are shown in figures 448 and 449. It is unfortunate that the photographs from which these figures are reproduced were not better. but they were the best it was possible to obtain.

The male was a typical Guernsey in respect to coat color and showed a very close approximation to the precise color pattern exhibited by his mother. The color of that part of his coat bearing pigmented hairs was a light yellowish fawn of the sort frequently seen in Guernseys and exactly the same as that of his mother. The similarity in color pattern between the male calf and his mother is shown in Fig. 448. The mother had a white triangle on the forehead like that of the bull calf; in the same

position and of relatively the same size. She also had on the right hind quarter a splash of white similar to that which is shown on the flank of the calf in Fig. 448. The coat color of this bull calf did not change substantially during life.

Both of the heifers of the triplets were typical Herefords, both as to color coat and to color pattern. The hair on the pigmented portions of the body was red in color. Both individuals showed the white face which is typical for Herefords. One of these heifers resembled her sire very closely in respect to details of color pattern. Although in Figures 448 and 449 these two heifers look very much alike, as a matter of fact they were not absolutely identical in respect to color pattern. Particular attention was paid to this point in studying these calves because of the possibility, if not probability, that the two females might be identical or enzygotic twins; that is that they might have arisen from the two first blastomeres of a single egg. Whether or not this was the case, at any rate the two individuals were not absolutely identical, quantitatively, in respect to color pattern. The coat color of the heifers darkened considerably during their lives. This darkening was not equally great in amount in both cases. In a letter of January 10, 1910 Mr. Walter had the following to say in regard to the condition of the triplets in respect to coat color at that time when they were nearly 3 years old. "One (of the heifers) is red and a perfect beauty. The other just a little taller, shades on the brown. Still they look very much alike. The bull is a typical Guernsey, larger than the heifers, well made and getting fine stock."

Externally the triplets gave no evidence of any abnormality or defect in the sexual organs. The bull was typically masculine in appearance and the heifers typically feminine. There was nothing whatever in the appearance of the heifers to suggest hermaphroditism. The bearing of this statement will be apparent when the breeding history of the triplets is completed.

3. *Description of Parents of Triplets.* The sire of these triplets was a grade Hereford showing the white face and body of nearly solid color typical for that breed. In his ancestry there was said to be a small admixture of Holstein "blood." Presumably in consequence of this arose the fact that his coat

Fig. 448. Photograph of triplet calves and dam.

Fig. 449. Photograph of triplet calves. Male calf in middle.

was black instead of dark red as is usual for the pure bred Hereford. He was an ordinary bull presenting no noteworthy characteristics of any kind. The owner stated to the writer that this bull had usually been prepotent in the matter of marking his calves. What this presumably meant, however, was that the calves of his get were in most cases white faced. This is probably to be regarded merely as an expression of the fact that Hereford white face is dominant in the Mendelian sense over most other types of coloration of the head region found in cattle.[26]

The sire was a relatively young bull. Particular inquiry was made when he was examined as to whether he had been known to get twin or triplet calves with relatively high frequency. The owner stated that this was distinctly *not* the case; that during the period this bull had been heading his herd twin calves had occurred, but not more frequently than was in general to be expected in breeding an equal number of cows. I was not able to obtain a photograph of the sire.

The dam of the triplets was a grade Guernsey, in conformation and color typical of the breed. She was born in 1900, and was, therefore, about 7 years old at the time the triplets were born. She bore her first calf when 2 years old. Her color was a light yellowish fawn splashed with white. She had a white triangle on the forehead and bands of white over the shoulders and rump. She was not a large cow even for a Guernsey. Some idea of her general conformation and color pattern may be gained from Fig. 448. Mr. Walter purchased the cow after acquiring the calves and states that she has proved to be a very good cow from the milking standpoint. It is of interest to note that this cow has two posterior, very small, supernumerary mammae. It is, of course, impossible to say whether this occurrence of supernumerary mammae is directly connected with the high degree of fecundity exhibited by this cow (see next section), but this may fairly be regarded as probably the case because of the fact that these two things are known to be associated in other forms. For example this is so in the sheep which Dr. Alexander Graham Bell[27] is breeding

[26]Cf. Spillman, W. J. Report of Committee on Hybridizing Animals. Rept. Amer. Breeder's Assoc. Vol. III, pp. 184-189, 1907.

[27]Bell. A. G. Sheep-Breeding Experiments on Beinn Breagh. Science. N. S. Vol. 36, pp. 378-384. 1912.

for increased fecundity at Beinn Breagh, Nova Scotia. Other examples of the same relationship might be cited.

TABLE I.

Breeding History of Dam of Triplets.

YEAR	BULL	Number of calves	SEX OF CALVES. ♂	♀	REMARKS.
1902	Grade "Durham"[28]: dark red.....	1	–		1 Calf like mother in color and color pattern.
1903	Grade Jersey: dark red body, black head and shoulders.	1	–		1 Calf black; white spot on forehead, white on end of tail. Kept 3 years and then killed.
1904	"Mongrel Jersey and Durham."	1	–		1 Calf resembled sire. Light color.
1905	Grade "Durham": red and white.	2	1		1 Calves red; premature birth in pasture, 1 dead when found. Other killed.
1906	Grade Holstein: black.	2	2	–	Calves black with white patches. Like father. Born dead.
1907	Grade Hereford: black, white face.	3	1		2 Present case.
1909[29]	Registered "Durham": Bates strain.	1	–		1 Calf had head and neck red with white star in face; body mixed with red but mostly white.
1910[30]	Grade Guernsey: the bull used in this case was the ♂ member of the set of triplets described in this paper.	3	1		2 Premature birth by two months. Thought to have been caused by cow falling on ice. All 3 calves alike in color and color pattern.
Totals.....		14	5		9

[28]"Durham" in this part of the country means actually Short-horn.

[29]Calf born March 21. 1909.

[30]Calves born in February, 1910.

4. *Breeding Record of Dam.* The complete breeding history of the mother of these triplet calves is given in Table I.

From this table the following points are to be noted:—

(a) During the life time of this cow she has been eight times pregnant. From these pregnancies there have been born 14 calves. This is certainly an unusually high, though by no means unique, degree of fecundity. It is an average production of one and three-quarters young per birth over the whole breeding life of the mother up to 1910.

In the literature of stock-breeding there are many records of cases of high fecundity in cattle. It is unnecessary to attempt any extensive review of these cases here. Of continuous high fecundity the following[31] case is of interest: A grade cow bore and raised 9 calves within 36 months. She had twins three times in succession, and in the next pregnancy triplets. The first twins were dropped in January 1876, and the triplets in December 1878. This gave an average of 2.25 young per birth. The highest continued record of fecundity for a cow which has come to my notice is that given by McGillivray in his "Manual of Veterinary Science and Practice" (1857) and later copied in many other veterinary works. The cow was of "the black polled breed" and is said to have been "small." Her breeding record was as follows:

Year	Number of calves at a birth.
1842	1—This was the cow's first calf.
1843	3—All lived to adult age.
1843	4—One died. (Seven calves in one year).
1844	2—Lived to maturity.
1845	3—Lived to maturity.
1846	6—All died prematurely.
1847	2—Came to maturity.
1848	4
Total	25—Mean number per birth = 3.125

(b) As regards the sex distribution of the offspring there is evidently a preponderance of females, taking the whole breeding life of the dam together. As the data are more carefully studied, however, it becomes apparent that the preponderance of females is a phenomenon due to the single rather than to the multiple births.

If the four multiple gestations in the life of this cow be taken together (that is, the pregnancies terminating in 1905,

[31]National Live Stock Jour. Vol. 10, p. 163, 1879.

1906, 1907 and 1910) it appears that of the 10 young born from these four pregnancies, 5 were males and 5 were apparently females. That is to say, they were females so far as external sexual characters were concerned. It is a curious fact that in all of the single births which this cow had the offspring were females. Whether this is merely a coincidence or has some deeper significance with reference to sex determination is not apparent.

(c) During the breeding history of this cow there has apparently been a steady increase in her rate of fecundity. The first three pregnancies resulted in single offspring, then came in succession two pairs of twins followed by triplets, and then, with a single pregnancy between another set of triplets. This would seem to indicate that as this cow is successively bred her tendency towards multiple gestation comes more and more into expression.

(d) The breeding history of this cow indicates that she has a definite and innate constitutional tendency towards multiple gestation, not due primarily to the action of external circumstances. If a normally uniparous animal has multiple births more than two or three times out of every ten births it is good evidence that the occurrence of such multiple gestation is not fortuitous but rests on an innate physiological tendency of the individual. In the present case there are four multiple births out of eight pregnancies. If there had been triplets but once in the breeding history of this cow, the occurrence might very well have been taken to be accidental. It is apparent, however, that for some reason this cow possesses a definite tendency to bear more than one young per birth. The tendency towards multiple gestation in this case cannot be due to rich or forced feeding. Neither of the two men who have owned the cow during her life have ever fed her heavy or rich rations. On the contrary she has been nourished during the greater part of her life on a relatively small amount of grain and a large amount of roughage.

(e) It is interesting to note that the sire of the last set of triplets (these born in 1910) was the male member of the former set of triplets borne by the same cow. It is in many ways

unfortunate that this last set of triplets was born prematurely. There would otherwise have been an excellent opportunity in this experiment of breeding the son back to the dam, when the son was a member of one set of triplets and the dam evidently had a definite and innate tendency towards multiple gestation, to get some interesting data in regard to the inheritance of this tendency towards high fecundity.

5. *The breeding record of the triplets.* The breeding records and sexual behavior of the individuals resulting from multiple gestation in cattle are of interest because of the fact of the occurrence of free-martins (infertile females) in the case of twin calves. Is the sterility and malformed or infantile condition of the genitalia in the free-martin casually related to the fact of multiple gestation, or do these things depend upon other and unrelated causes? Any information regarding the breeding behavior of individuals arising from multiple gestations is welcome in this connection. The writer asked Mr. Walter, the owner of the calves here described, to pay particular attention to the sexual behavior of these triplets. This was done. As has already been implied in what has gone before the male individual of the triplets was entirely functional sexually. He was used in service locally; got good calves; and apparently got as high a proportion of calves as would be expected from a bull of his age. In regard to the sexual history of the female individuals of the triplets, Mr. Walter has the following to say in a letter dated April 11, 1910. After noting the fact that these two supposed heifers had been killed and sold in the village market he says:—"Neither of them had ever been in heat and the man that dressed them said that they would never have bred." In earlier letters Mr. Walter on several occasions said that these calves never showed the slightest signs of being in heat. From the account given by the butcher who killed these animals[32] it appears probable (though, of course, too much weight cannot be put upon such information) that in both individuals the conditions were such as have been described for many free-martins. Neither uterus or tubes were recognized but the vagina apparently ended at its anterior

[32]Unfortunately it was not possible for the writer to be present at this time.

end as a blind sack. Although detailed anatomical data are lacking, there can be little doubt, I believe, because of both the physiological fact of absence of oestrus and the lack (?) or minute, infantile condition of uterus and Fallopian tubes, that these two supposed female individuals were really free-martins.

6. *Color Inheritance in the Triplets.* The coat color and pattern exhibited by these triplets are matters of considerable interest. The essential points in regard to color inheritance in this case are:

(a) That the two females were not at all like the male in either color or pattern. They were of the Hereford type of color and pattern, while the bull was of the Guernsey color and pattern.

(b) While the two females were in general alike in coat color and pattern they were very far from being identical. Especially as they grew older they came to differ quite considerably in color. From the beginning they were distinctly different in pattern.

The sire and dam of these triplets were both grade animals of very mixed ancestry. This makes impossible any attempt to interpret precisely the color inheritance. It is possible, however, by making one or two not improbable assumptions to reach a simple Mendelian interpretation[33] of the inheritance of color and color pattern in these triplets. Such an interpretation can be, of course, only hypothetical, but it is not without interest.

The most striking difference between the sire and dam in regard to color pattern is that the sire had the Hereford white face, and the dam did not. The Hereford white face is known to be dominant over colored face. From the data regarding the breeding of the sire it is reasonable to suppose that he was heterozygous with reference both to head pattern, and to coat color (cf. p. 274 *supra*). The case regarding the dam is not so clear. From the meager data available in regard to her calves born before the present triplets (*vide* Table 1.) it seems probable that with regard to

[33]The essential features of this interpretation were first suggested to the writer by Mr. W. J. Spillman, in the course of some correspondence in regard to the case.

head pattern she is homozygous for the absence of white face. Let us assume this to be the case, and also assume[34] that she is heterozygous, with reference to body color, the Guernsey fawn being the assumed dominant over red.

Then we may suppose the male of the triplets to be a homozygous recessive with reference to colored face, and a heterozygous dominant in respect to body color (Guernsey). The females of the triplets on this assumption would be heterozygous with reference to face pattern (the dominant white face showing) and pure recessives relative to body color. The only way, of course, to have tested the validity of these assumptions would have been to have bred the triplets and examined their progeny. While the male was bred back to his dam, I was not able to get any information as to the color or pattern of the progeny except that all were alike in these respects. This would be expected on the hypothesis made so far as face color is concerned since the son and his dam were supposed pure recessives with reference to colored face. In regard to body color the case is more difficult but it is useless to speculate in the absence of more detailed data regarding the offspring.

Summary.

In the introductory portion of this paper there is presented a discussion of the general biological problems on which cases of multiple gestation in normally uniparous animals bear. The essential purpose of this discussion is to suggest points on which information should be collected by those having an opportunity to observe such cases. These are:

(a) The physiology of multiple gestation.

(b) The determination of sex. Young from multiple gestations in normally uniparous animals exhibit marked and regular deviations from the sex ratios observed in single births of the some species. This fact is of significance in connection with the question of the degree to which sex determination is an epigenetic phenomenon.

[34]It is difficult to get data to test this assumption because of the rarity with which pure Guernseys and pure Shorthorns or Herefords are cross-bred.

(c) The development of secondary sexual characters.

(d) The inheritance of fecundity and fertility. It is well established that a tendency to multiple gestation in normally uniparous forms may be inherited, and may be made the basis of building up more fertile strains or breeds.

The discussion of problems is followed by a detailed description of a case of triplet calves, borne by a cow apparently having an innate inherited tendency towards multiple gestation.

The triplets were the progeny of a grade Guernsey cow that produced 14 calves in her first eight pregnancies, bearing triplets twice, twins twice, and single young four times.

The growth of multiple as compared with single young is discussed with reference to certain general laws of growth.

The triplets described consisted of two females and one male. The latter was sexually normal in every particular, and was used in service, getting normal offspring. The females never came in heat and probably were free-martins.

In color and pattern inheritance the triplets exhibited the following peculiarities: The male was typically a Guernsey, resembling closely his dam. The females were of quite different color and pattern, resembling more closely their sire, a grade Hereford. A possible Mendelian interpretation of these facts is discussed.